

CLAIMS:

1. A process for forming an aryl-aryl bond comprising the step of reacting an arene hydrocarbon compound with an organic oxidant selected from the group consisting of a quinone, a quinone imine, a quinone diimine, and a
5 nitroarene, in the presence of a Brönsted or Lewis acid.
2. The process of claim 1 in which the organic oxidant includes a substituted or unsubstituted quinone.
- 10 3. The process of claim 1 in which the organic oxidant includes a quinone selected from the group consisting of 2,3-dichloro-5,6-dicyanobenzoquinone, 1,4-benzoquinone, 1,2-benzoquinone, *o*-tetrafluorobenzoquinone, *p*-tetrafluorobenzoquinone, tetracyanobenzoquinone, *o*-chloranil, *p*-chloronil, 1,4-naphthoquinone, anthraquinone, 2,6-
15 diphenylbenzoquinone, 2,6-di-*tert*butylbenzoquinone.
4. The process of claim 1 in which the organic oxidant includes a nitroarene.
- 20 5. The process of claim 1 in which the organic oxidant includes a nitroarene selected from the group consisting of nitrobenzene, 1,2-dinitrobenzene, 1,3-dinitrobenzene and 1,4-dinitrobenzene
6. The process of claim 1 in which the organic oxidant is a
25 nitrobenzene.
7. The process of claim 1 conducted in the presence of a Brönsted acid selected from the group consisting of trifluoromethanesulfonic acid, trifluoroacetic acid, phenylsulfonic acid, methanesulfonic acid, trichloroacetic
30 acid, dichloroacetic acid, fluoroacetic acid, chloroacetic acid, formic acid, fluorosulfonic acid, sulfuric acid, tetrafluoroboronic acid, acetic acid, and benzoic acid.

8. The process of claim 1 conducted in the presence of a Lewis acid selected from the group consisting of BF_3 , $\text{BF}_3 \cdot (\text{C}_2\text{H}_5)_2\text{O}$, BCl_3 , AlCl_3 , $\text{Al}(\text{CH}_3)_3$, TiCl_4 , ZrCl_4 , SnCl_4 , $\text{SnCl}_4 \cdot 5\text{H}_2\text{O}$, SnF_4 , VCl_4 , SbF_5 , ScCl_3 , $\text{ScCl}_3 \cdot 6\text{H}_2\text{O}$, $\text{Sc}(\text{CF}_3\text{SO}_3)_3$, $\text{La}(\text{CH}_3\text{CO}_2)_3 \cdot \text{X H}_2\text{O}$, LaCl_3 , $\text{LaCl}_3 \cdot 7\text{H}_2\text{O}$, LaF_3 , $\text{La}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$, $\text{La}(\text{C}_2\text{O}_4)_3 \cdot \text{xH}_2\text{O}$, $\text{La}(\text{SO}_4)_3 \cdot \text{xH}_2\text{O}$, $\text{La}(\text{CF}_3\text{SO}_3)_3$, ZnCl_2 , ZnBr_2 , ZnF_2 , $\text{Zn}(\text{CH}_3\text{CO}_2)_2$, $\text{Zn}(\text{CH}_3\text{CO}_2)_2 \cdot 2\text{H}_2\text{O}$, $\text{ZnSiF}_6 \cdot \text{xH}_2\text{O}$, $\text{Zn}(\text{NO}_3)_2 \cdot \text{xH}_2\text{O}$, $\text{Zn}(\text{C}_2\text{O}_4)_2 \cdot \text{xH}_2\text{O}$, and $\text{Nd}(\text{CF}_3\text{SO}_3)_3$.
9. The process of claim 1 conducted in presence of both a Lewis acid and a Brönsted acid.
10. The process of claim 1 in which the reaction is terminated by a quenching agent.
11. The process of claim 1 in which the reaction is terminated by a quenching agent which is a compound capable of a reductive electron transfer process.
12. The process of claim 1 in which the reaction is terminated by a quenching agent selected from the group consisting of silver, magnesium, zinc, manganese, iron, cobalt, sodium, potassium, aluminum, ferrocene, zirconocene, lithium, tin, methanol, ethanol, triethylamine, triphenylamine, trimethoxybenzene.
13. The process of claim 1 in which the reaction is terminated by a quenching agent which is a metal-organic complex capable of a reductive electron transfer process.
14. The process of claim 13 in which the quenching agent is ferrocene.
15. The process of claim 1 conducted at a temperature between -20°C and 85°C .

16. The process of claim 1 in which the reaction temperature is less than 25° C.

5 17. A process for forming an aryl-aryl bond comprising the step of reacting two arene hydrocarbon molecules with an organic oxidant, selected from the group consisting of a quinone, a quinone imine, a quinone diimine, and a nitroarene, in the presence of a Brönsted or Lewis acid to form an intermolecular bond between the two molecules.

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18. The process of claim 17 in which the organic oxidant is a substituted or unsubstituted quinone.

15 19. The process of claim 17 in which the arene hydrocarbon compound is a polycyclic aromatic hydrocarbon.

20. The process of claim 17 in which the arene hydrocarbon is selected to form a bis-fluoranthene compound.

20 21. The process of claim 17 in which the arene hydrocarbon is selected to form a diindeno[1,2,3-cd:1',2',3'-1m]perylene capable of fluorescent emission in the green to red region of the visible absorption spectrum.

22. The process of claim 17 in which the arene hydrocarbon is selected to form an indenoperylene[1,2,3-cd]perylene compound.

23. The process of claim 17 in which the arene hydrocarbon is selected to form a perylene compound.

30 24. The process of claim 17 in which the arene hydrocarbon is selected to form a bis-anthracene compound.

25. The process of claim 17 in which the arene hydrocarbon is selected to form a bis-pyrene compound.

26. The process of claim 17 in which the reaction is terminated by
5 contact with a quenching agent.

27. A process for forming an aryl-aryl bond comprising the step of reacting a single arene hydrocarbon molecule with an organic oxidant selected from the group consisting of a quinone, a quinone imine, a quinone diimine, and a
10 nitroarene, in the presence of a Brönsted or Lewis acid, to form an intramolecular bond effecting the formation of a carbocyclic ring.

28. The process of claim 27 in which the arene hydrocarbon is selected to form intramolecularly a five-membered carbocyclic ring or to form
15 intramolecularly a six-membered carbocyclic ring.

29. The process of claim 27 in which the organic oxidant is a substituted or unsubstituted quinone.

20 30. The process of claim 27 in which the reaction is terminated by a quenching agent.

31. The process of claim 10 in which the arene hydrocarbon is 7,12-diphenylbenzo[k]fluoranthene (XV), the organic oxidant is 2,3-dichloro-5,6-
25 dicyanobenzoquinone, the Brönsted acid is trifluoroacetic acid, the Lewis acid is boron trifluoride diethyletherate, and the quenching agent is ferrocene and the product is dibenzo {[f,f']-4,4',7,7'-tetraphenyl}-diindeno[1,2,3-cd:1',2',3'-lm]perylene.

30 32. The process of claim 10 in which the arene hydrocarbon is (3-(1-naphthyl)-7,12-diphenylbenzo[k]fluoranthene), XIX, the organic oxidant is 2,3-dichloro-5,6-dicyanobenzoquinone, the Brönsted acid is trifluoroacetic acid, the

Lewis acid is boron trifluoride diethyletherate, and the quenching agent is ferrocene and the product is benzo {[f]-4,7-diphenyl}-indeno[1,2,3-*cd*]perylene.

33. The process of claim 10 in which the arene hydrocarbon is **XVI**,
5 the organic oxidant is nitrobenzene, the Brönsted acid is trifluoromethanesulfonic acid, and the quenching agent is triethylamine.

34. A process for forming an aryl-aryl bond comprising the step of
10 reacting an arene hydrocarbon compound with an oxidizing salt selected from the group consisting of a triarylaminium salt, an oxonium salt, and a nitrosium salt, in the presence of a Brönsted or Lewis acid.

35. The process of claim 34 in which the oxidizing salt includes an
15 triarylaminium salt selected from the group consisting of tris-(4-bromophenyl)aminium hexachloroantimonate and tris-(2,4-dibromophenyl)aminium hexachloroantimonate.

36. The process of claim 34 conducted in the presence of a Brönsted
20 acid selected from the group consisting of trifluoromethanesulfonic acid, trifluoroacetic acid, phenylsulfonic acid, methanesulfonic acid, trichloroacetic acid, dichloroacetic acid, fluoroacetic acid, chloroacetic acid, formic acid, fluorosulfonic acid, sulfuric acid, tetrafluoroboronic acid, acetic acid, and benzoic acid.

37. The process of claim 34 conducted in the presence of a Lewis acid
25 selected from the group consisting of BF_3 , $\text{BF}_3 \cdot (\text{C}_2\text{H}_5)_2\text{O}$, BCl_3 , AlCl_3 , $\text{Al}(\text{CH}_3)_3$, TiCl_4 , ZrCl_4 , SnCl_4 , $\text{SnCl}_4 \cdot 5\text{H}_2\text{O}$, SnF_4 , VCl_4 , SbF_5 , ScCl_3 , $\text{ScCl}_3 \cdot 6\text{H}_2\text{O}$, $\text{Sc}(\text{CF}_3\text{SO}_3)_3$, $\text{La}(\text{CH}_3\text{CO}_2) \cdot \text{X} \cdot \text{H}_2\text{O}$, LaCl_3 , $\text{LaCl}_3 \cdot 7\text{H}_2\text{O}$, LaF_3 , $\text{La}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$, $\text{La}(\text{C}_2\text{O}_4)_3 \cdot x\text{H}_2\text{O}$, $\text{La}(\text{SO}_4)_3 \cdot x\text{H}_2\text{O}$, $\text{La}(\text{CF}_3\text{SO}_3)_3$, ZnCl_2 , ZnBr_2 , ZnF_2 ,
30 $\text{Zn}(\text{CH}_3\text{CO}_2)_2$, $\text{Zn}(\text{CH}_3\text{CO}_2)_2 \cdot 2\text{H}_2\text{O}$, $\text{ZnSiF}_6 \cdot x\text{H}_2\text{O}$, $\text{Zn}(\text{NO}_3)_2 \cdot x\text{H}_2\text{O}$, $\text{Zn}(\text{C}_2\text{O}_4)_2 \cdot x\text{H}_2\text{O}$, and $\text{Nd}(\text{CF}_3\text{SO}_3)_3$.

38. The process of claim 34 conducted in presence of both a Lewis acid and a Brönsted acid.

39. The process of claim 34 in which the reaction is terminated by
5 contact with a quenching agent.

40. The process of claim 34 in which the reaction is an intermolecular reaction between two different molecules.

10 41. The process of claim 34 in which the reaction is an intramolecular reaction of a single molecule to form an intramolecular bond effecting the formation of a carbocyclic ring.

42. A process for forming an aryl-aryl bond comprising the step of
15 reacting an unactivated arene hydrocarbon compound with a hypervalent iodine compound in the presence of a Brönsted or Lewis acid.

43. The process of claim 42 in which the hypervalent iodine oxidant is selected from the group consisting of bis-trifluoroacetoxyiodobenzene and bis-acetoxyiodobenzene.
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44. The process of claim 42 conducted in the presence of a Brönsted acid selected from the group consisting of trifluoromethanesulfonic acid, trifluoroacetic acid, phenylsulfonic acid, methanesulfonic acid, trichloroacetic
25 acid, dichloroacetic acid, fluoroacetic acid, chloroacetic acid, formic acid, fluorosulfonic acid, sulfuric acid, tetrafluoroboronic acid, acetic acid, and benzoic acid.

45. The process of claim 42 conducted in the presence of a Lewis acid
30 selected from the group consisting of BF_3 , $\text{BF}_3 \cdot (\text{C}_2\text{H}_5)_2\text{O}$, BCl_3 , AlCl_3 , $\text{Al}(\text{CH}_3)_3$, TiCl_4 , ZrCl_4 , SnCl_4 , $\text{SnCl}_4 \cdot 5\text{H}_2\text{O}$, SnF_4 , VCl_4 , SbF_5 , ScCl_3 , $\text{ScCl}_3 \cdot 6\text{H}_2\text{O}$, $\text{Sc}(\text{CF}_3\text{SO}_3)_3$, $\text{La}(\text{CH}_3\text{CO}_2) \cdot \text{X H}_2\text{O}$, LaCl_3 , $\text{LaCl}_3 \cdot 7\text{H}_2\text{O}$, LaF_3 , $\text{La}(\text{NO}_3)_3$.

6H₂O, La(C₂O₄)₃ · xH₂O, La(SO₄)₃ · xH₂O, La(CF₃SO₃)₃, ZnCl₂, ZnBr₂, ZnF₂, Zn(CH₃CO₂)₂, Zn(CH₃CO₂)₂, Zn(CH₃CO₂)₂ · 2H₂O, ZnSiF₆ · xH₂O, Zn(NO₃)₂ · xH₂O, Zn(C₂O₄)₂ · xH₂O, and Nd(CF₃SO₃)₃.

5 46. The process of claim 42 conducted in presence of both a Lewis acid and a Brönsted acid.

 47. The process of claim 42 in which the reaction is terminated by contact with a quenching agent.

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 48. The process of claim 42 in which the reaction is an intermolecular reaction between two different molecules.

 49. The process of claim 42 in which the reaction is an intramolecular
15 reaction of a single molecule to form an intramolecular bond effecting the formation of a carbocyclic ring.